

NOAA California Bay Watershed Education and Training Program

1. PROJECT SUMMARY

Organization: Exploratorium
Principal Investigator: [REDACTED]
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Partners: Gulf of the Farallones National Marine Sanctuary
National Estuarine Research Reserve
San Francisco Unified School District
Oakland Unified School District

Priority Areas: Priority 2: Professional Development in the Area of Environmental Education for Teachers

Project Title: *Interpreting the Bay*

Project Duration: August 2013 – July 2014

Summary of work:

The Exploratorium Teacher Institute (TI) will design and implement a professional development program, *Interpreting the Bay*, for San Francisco Bay Area middle and high school science teachers. Two NOAA entities, the Gulf of the Farallones National Marine Sanctuary and the National Estuarine Research Reserve, will provide content and resources for meaningful watershed experiences for participants. The San Francisco Unified School District and the Oakland Unified School District will partner to recruit teachers and disseminate curriculum.

Building on prior work sponsored by NOAA B-WET and the S. D. Bechtel, Jr. Foundation, this project focuses on strengthening teacher content knowledge and pedagogy skills to teach about making and using tools to take data from the San Francisco Bay and using data to understand the state of the watershed. TI will create and offer two types of professional development opportunities: 1) an intensive one-week, 32.5-hour Summer Institute that incorporates meaningful watershed experiences at the Exploratorium’s new location on the San Francisco waterfront and 2) four Saturday watershed content workshops held during the school year. Teachers will be selected for their leadership capacity, with preference given to teams from the same school, and teachers will receive support to share their knowledge with peers.

Interpreting the Bay will spend \$678 per teacher, for 125 teachers serving 18,750 students a year, and provide a total of 1,312.5 professional development contact hours.

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2. PROJECT DESCRIPTION

The Exploratorium Teacher Institute (TI) proposes to create and implement a one-year professional development program, *Interpreting the Bay*, for San Francisco Bay Area middle and high school science teachers. By combining classroom activities and field experiences related to the San Francisco Bay, the Gulf of the Farallones National Marine Sanctuary (GFNMS), and the National Estuarine Research Reserve (NERR), the program will strengthen participants' content knowledge and pedagogical skills regarding measurement tools, data collection, and data analysis in their local watershed. Workshops will combine place-based learning strategies with inquiry-rich, hands-on classroom activities that develop teacher and student knowledge and critical thinking skills. For the past few years, TI has built experience and resources in providing teacher professional development in environmental science and is committed to establishing long-term programs in environmental science. Building on this prior work, *Interpreting the Bay* is timed to coincide with the opening of the Exploratorium's new location on the San Francisco waterfront as well as the introduction of the Next Generation Science Standards and will take advantage of the educational opportunities provided by those events.

This project consists of two main activities: 1) a one-week, 32.5-hour *Interpreting the Bay* Summer Institute and 2) four 5-hour Saturday workshops offered during the school year. TI will train and support 125 science teachers through these activities. The project will also provide 25 teacher participants with classroom visits by staff from GFNMS. Additionally, teachers will be supported to share their knowledge with peers.

2A. Need

Slated for adoption in 2013, the Next Generation Science Standards (NGSS) are organized along three dimensions: science and engineering practices, crosscutting concepts, and disciplinary core ideas (www.nextgenscience.org). Watershed science is an ideal example of content that supports student engagement in authentic science practices, helps students understand the big ideas that link the sciences (i.e., energy and matter), and highlights the interdisciplinary nature of environmental research. However, secondary science teachers typically hold single-subject credentials, and few have formal training in the combined areas of earth, life, and physical sciences needed to teach about the watershed effectively. Moreover, most teachers have little

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support or training using project-based learning activities¹, although such student-centered investigations increase motivation by making science more relevant². Science teachers need support that engages them directly in effective learning experiences, strengthens their content knowledge across many disciplines, develops best practices, prepares them for leadership, and is embedded in a community of practice³.

In spring 2013, the Exploratorium will move to a new, expanded space at Piers 15/17 on the San Francisco Bay that will provide the museum with an exceptional opportunity to offer many more programs focused on the marine environment. A major new investment at the piers is the construction of the Observatory, a gallery strategically designed to collect data from both the San Francisco Bay's aquatic environment and the city's urban landscape. The exhibits, programs, and instruments in the Observatory will be the creative engine and public face of new curricular work in the complex environment of the San Francisco Bay. The Observatory includes a project funded by the Gordon and Betty Moore Foundation called the Wired Pier, a set of state-of-the-art sensors and scientific instruments sited on the roof and in the water that will collect information on observable phenomena as well as data about the atmospheric and aquatic conditions, such as temperature, weather, and tidal data. These instruments will allow teachers and museum visitors to track ever-changing bay and ocean environments over time and learn how sensor data is used to generate predictive models. The Observatory will have an observing station featuring real-time site conditions as well as data visualizations, imagery, and video streams from local and remote research locations. With its location and resources, the Observatory and Wired Pier will distill complicated data into tangible meaning for teachers and visitors and are ideally suited to provide meaningful watershed experiences.

The professional development curriculum content of *Interpreting the Bay* will focus on helping teachers understand both the tools and data collected through the Wired Pier and other NOAA data sources. The goal is for the science teachers to learn how to interpret the data to draw empirically based conclusions about the state of the San Francisco Bay, thus relating current science research to the first principles taught in the classroom. Participating science teachers will engage in the kinds of inquiry-rich activities and authentic watershed research experiences that have been identified as critical elements of successful environmental science professional

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development⁴. This project will also show teachers how to translate their experiences at the Exploratorium into meaningful student learning activities. Teachers will learn to construct simple, inexpensive tools that students can use back in classrooms. These tools will collect data analogous to the more sophisticated instrumentation at the Wired Pier and can be used to explore the properties of water and engage in watershed research at their school sites. By highlighting watershed research instruments, this project emphasizes both the science content behind data measurements and shows teachers how to integrate the science and engineering practices stressed in the NGSS.

Since 2010, TI has offered an environmental science professional development program called *Watershed Education Training: Fostering Environmental Experiences for Teachers (WET FEET)*, which has been funded by NOAA B-WET (NA10NOS4290069) and the S. D. Bechtel, Jr. Foundation. *WET FEET*, currently in its final year, combined the delivery of hands-on science activities with place-based learning and was focused on teacher professional development in watershed science, including the impact of plastics and marine debris, the water cycle, and water chemistry. Evaluations of *WET FEET* indicated that participating teachers improved their content knowledge, led students in the activities and explorations learned during workshops, and involved their science classes in place-based environmental science. Participants clearly indicated that they wanted additional professional development training focused on watershed science. In this last year of *WET FEET*, TI has begun prototyping activities that involve constructing simple environmental data collection tools that can be used in the classroom and in the field. Results from this pilot work are discussed in Section 6.

In *Interpreting the Bay*, TI will build on the success of *WET FEET* by creating and providing professional development activities in areas of watershed science that generated the greatest teacher interest and are most closely aligned to NOAA's Education Plan and Ocean Literacy Principles. *WET FEET* showed that teachers improved their watershed content knowledge by directly interacting with the instruments and tools used to conduct research. Therefore, *Interpreting the Bay* content areas will be explored through the lens of data collection and analysis, which will incorporate engineering practices and cross-curricular themes specified in the NGSS. Teachers will have the opportunity to participate in place-based watershed

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experiences at the Exploratorium and GFNMS and will learn how to translate those experiences to classrooms and school sites.

2B. Target Audience

The primary audience for *Interpreting the Bay* is middle and high school science teachers in the San Francisco Unified School District (SFUSD) and Oakland Unified School District (OUSD). Both serve high percentages of traditionally underserved students (Table 1). TI has worked with teachers serving in these districts and others with similar populations for 28 years.

Table 1. Ethnic and social demographics for SFUSD and OUSD (2010-11)⁵

District	American Indian	Asian/Pacific Is	Hispanic	African American	White	English learners	Free lunch
SFUSD	<1%	45%	24%	11%	11%	29%	60%
OUSD	<1%	15%	40%	32%	8%	26%	70%

SFUSD has recently begun an ecoliteracy education initiative, led by TI alumna Sarah Delaney, Ecoliteracy Content Specialist, to ensure students are aware of their impacts on the local environment and provide opportunities to take personal action through science. Providing professional development to foster meaningful watershed experiences will specifically support SFUSD and its teachers reach their goal of graduating ecoliterate students.

In total, *Interpreting the Bay* will directly develop the knowledge and skills of up to 125 science teachers responsible for approximately 18,750 secondary students every year (125 teachers x 150 students/teacher). Additionally, this project will impact existing GFNMS programs, which currently reach over 6,000 teachers and students a year, and further expand their audience by supporting new classroom visits. By providing resources and incentives for participating teachers to disseminate information to other teachers, this project has the potential of reaching many additional educators and students.

2C. Participant Recruitment

TI has worked with SFUSD and OUSD for its entire history. In this project, district science coordinators will promote the program and identify and recruit teacher participants (see letters of support). In addition, TI will advertise the Summer Institute and Saturday workshops online and

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to its alumni network, with preference given to teachers from target districts. The TI alumni community includes more than 2,700 middle and high school science teachers, all of whom have completed an intensive multi-week Summer Institute. TI participants are eligible to receive professional development for their entire careers, and this model of lifelong professional development provides the capacity to use the project's resources beyond the lifetime of the grant.

Evaluation of a recent week-long TI Summer Institute found that teachers who participated with colleagues from their schools were more active in using the provided collaboration time for long-term planning and discussing the integration of workshop content and activities into their curricula. Therefore, teachers will be encouraged to apply in teams with other teachers from their schools to promote sustained collaboration after the project. Teachers will receive stipends for participation in any *Interpreting the Bay* activity, and those who attend the Summer Institute will be eligible for continuing education credits.

2D. Objectives

Interpreting the Bay will directly support the California B-WET Program Priority (2) Professional Development in the Area of Environmental Education for Teachers. As an overarching goal, this project will strengthen the knowledge, skills, and capacities of middle and high school science teachers to facilitate meaningful watershed experiences for students that are both place-based and classroom-based.

Curriculum content will align with the NOAA Education Strategic Plan and Essential Principles of Ocean Literacy as well as the California Science Content Standards, California Education and Environment Initiative, and the NGSS (see Section 2.F.f). Utilizing NOAA partners and curriculum resources, this project seeks to meet the following objectives.

Objective 1: To **improve the watershed science content knowledge** of middle and high school science teachers in alignment with the NOAA Education Plan, NOAA Ocean Literacy Principles, California Science Content Standards, California Education and Environment Initiative, and the Next Generation Science Standards through data

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collection and analysis in their local watersheds, San Francisco Bay, and Gulf of the Farallones National Marine Sanctuary.

Objective 2: To **strengthen the pedagogical skills and broaden the teaching repertoire** of middle and high school science teachers so that they can understand the essence of a meaningful watershed experience and effectively teach environmental science by taking and interpreting data from their local watersheds, San Francisco Bay, and Gulf of the Farallones National Marine Sanctuary.

Objective 3: To **promote collaboration, communication, and peer-to-peer sharing** among teachers to disseminate science content, pedagogy, and activities that support successful watershed learning experiences for all teachers and students.

Objective 4: To **increase the capacity of Gulf of the Farallones National Marine Sanctuary** to provide in-school programming by enhancing curriculum content and building relationships with secondary school teachers.

The outputs used to meet these objectives are described in Section 2E. Methods for achieving each objective and how they connect to NOAA Program Priorities are highlighted in Section 2F.

2E. Program Content

Interpreting the Bay will offer professional development opportunities to SFUSD and OUSD science teachers and other TI alumni on learning watershed science through data collection and interpretation. The program includes hands-on activities and investigations, place-based learning, and watershed experiences. The primary program elements are described below.

Interpreting the Bay Summer Institute

TI will develop and implement a weeklong, 32.5-hour Summer Institute that will focus on the scientific tools and instruments used to collect data from the watershed. Activities will include constructing tools made from inexpensive materials to collect data from the Bay, such as a hydrometer, water sampler, and Secchi disk. Teachers will analyze and interpret data that they

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collect and compare it to data from the Exploratorium's Wired Pier and from NERR, thereby strengthening their understanding of watershed science content. Content areas addressed will support Ocean Literacy Principles 1 (The Earth has one big ocean with many features) and 6 (The ocean and humans are inextricably interconnected), such as water chemistry (salinity, density, and temperature), ocean acidification, and biology of the watershed. NOAA curriculum materials such as the Water Quality and Ocean Acidification modules from *Data in the Classroom* (<http://www.dataintheclassroom.org>) will be highlighted. Teachers will also be shown how to use emerging technologies, including the NOAA-sponsored *Marine Debris Tracker* app (<http://www.marinedebris.engr.uga.edu>) to help teachers and their students make connections to the global impacts of their local actions. Exploratorium Staff Scientist Ron Hipschman will co-lead the Summer Institute sessions focused on the museum's instrumentation. As part of the Wired Pier project, Hipschman is developing ways for the public to understand the data collected at the Observatory.

During each 6.5-hour day, teachers will spend four hours in class and two and a half hours working on: 1) meeting in small groups to adapt workshop content and activities to their own curricula, resulting in the creation of standards-based teaching units; or 2) constructing site-specific versions of watershed data collection tools to be used at their schools. Summer Institute participants will receive classroom materials and stipends of \$325. They will also be eligible for continuing education credits offered through the University of the Pacific.

After the Summer Institute, participants will share the products of the collaboration time and other *Interpreting the Bay* curricula with colleagues in their schools and districts. Teachers will document post-Summer Institute peer-to-peer sharing in Teacher Portfolios and will receive \$100 for completing this program element.

Saturday Content Workshops

This project will also provide four 5-hour Saturday professional development workshops. Held during the academic year, Saturday sessions provide teachers a means for long-term involvement with TI, where they can return to caucus with colleagues and rejuvenate their teaching with new activities and ideas. Highest priority will be given to *Interpreting the Bay* Summer Institute

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participants and to teachers from partner districts. Teachers will be encouraged to attend the Saturday workshops with at least one colleague from their schools. Saturday topics will address data collection and watershed science and will be developed from suggestions of summer participants. Prospective topics include ocean chemistry, marine debris, and water quality.

One Saturday session will be presented in collaboration with GFNMS and will focus on a NOAA high-priority content area, such as ocean acidification. Held at the GFNMS site near the Golden Gate Bridge, this workshop will provide opportunities for place-based activities that create a meaningful watershed experience. Justin Holl, GFNMS Visitor Center Manager, and the GFNMS staff will guide teachers through hands-on activities using water samples taken directly from the sanctuary. *Interpreting the Bay* will also pay for GFNMS to visit the classrooms of teachers who attend this workshop (normally a cost of \$75 per visit). GFNMS has been seeking ways to reach more secondary science teachers, and this is designed to increase their audience.

In another Saturday Workshop, Sarah Ferner, NERR Education Coordinator, will introduce Hobo™ data loggers as a tool for collecting multiple types of data from the watershed. These small, electronic, classroom-friendly data collection tools can be used in terrestrial or aquatic environments. Sarah will work with TI staff prior to the Saturday workshop to build TI's capacity to use this technology. During the workshop, teachers will be able to develop their own research questions, conduct their own investigations, and compare their data with the data that NERR uses for research. Participants will receive a \$50 stipend for each Saturday workshop.

2F. Program Priorities

a. Providing teachers the understanding and essence of a Meaningful Watershed Educational Experience

Interpreting the Bay will use place-based pedagogies to involve teachers in making observations and gathering and interpreting data. TI will apply its long history of understanding and teaching science through hands-on investigations to teaching watershed science through classroom explorations as well as place-based experiences in watershed locations. Teachers will be based at the Exploratorium's new Piers 15/17 location and will visit the Gulf of the Farallones National Marine Sanctuary Visitor Center, both directly on the San Francisco Bay, to use professional

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instrumentation for watershed data collection, construct and use classroom tools to conduct water research, and be trained to do similar work in their school environments (Objectives 1 and 2).

This project will provide professional development through a Summer Institute, which can accommodate 25 teachers, and four Saturday workshops, each of which can accommodate 25 teachers. This provides the opportunity for up to 125 teachers to attend, although some participants may attend multiple workshops, resulting in more professional development hours for fewer teachers. The program will provide a total of 1,312.5 professional development contact hours, with a single teacher receiving between 5 and 52.5 contact hours. All TI alumni have had a minimum of 100 professional development hours with TI, with the majority having many more contact hours over their years of participation. New participants will be invited to attend future TI programs and receive continued support. This long-term relationship allows TI to support teachers with content and resources throughout their careers and ensures the sustainability of the project. Teachers visited by GFNMS will be further supported in their classrooms with NOAA staff providing meaningful watershed experiences directly to their students (Objective 4).

b. Promoting external sharing and communication

To facilitate dissemination, TI will provide collaboration time and resources during the Summer Institute for teachers to work together on long-term planning and dissemination opportunities (Objective 3). This support will enable teachers to share their work via: 1) school or district professional development days and 2) local and national science teacher conferences, such as the California Science Teacher's Association, National Science Teacher's Association, and Council of Math/Science Educators of San Mateo County. As an incentive, each teacher will be given a \$100 stipend for completing a Teacher Portfolio that describes their peer-to-peer dissemination (see Section 5 and supporting documents).

In addition, teacher professional development strategies, hands-on activities, and classroom lessons will be disseminated to partner organizations. Curriculum developed in NOAA high-priority content areas will be used by GFNMS in their programs and shared with other NOAA organizations (Objective 4). The *Interpreting the Bay* curricula will become part of the collection of science education resources available on the TI Web site (www.exploratorium.edu/ti), where

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they will also be accessible to other NOAA B-WET projects as well as educators around the world. TI staff will also present workshops and short courses on integrating meaningful watershed experiences into environmental education curricula at local and national conferences.

c. Fostering and utilizing meaningful partnerships

Interpreting the Bay will strengthen the relationships between TI and GFNMS and NERR, both partners in the earlier *WET FEET* project. GFNMS and NERR have committed to providing content and expertise and will enhance critical place-based experiences to help participants make meaningful interpretations of real data and observations taken by NOAA as well as by the teachers themselves (see letters of support). TI will help build the capacities of the partner organizations to provide meaningful watershed educational experiences by expanding their target audiences and developing site-appropriate hands-on activities to complement their programs (Objectives 1, 2, and 3). TI will work with GFNMS to deliver a Saturday Workshop in a content area that supports GFNMS in-class programming. *Interpreting the Bay* will sponsor a classroom visit by GFNMS to any teacher who participates in that Saturday Workshop. GFNMS currently conducts around 100 site visits in their in-school programs and would like to increase their reach to secondary schools (Objective 4). TI has successfully collaborated with GFNMS to deliver workshops in the past, and sponsoring classroom visits will prototype a way to enhance the partnership and extend the reach and effectiveness of both programs.

d. Providing experiences for all teachers

TI has long been committed to providing professional development to science teachers in school districts serving ethnically diverse student populations (Table 1). Over the last 28 years, TI has partnered with SFUSD and OUSD on numerous, multi-year, multi-million dollar science teacher professional development initiatives funded by the National Science Foundation and the California Department of Education. The hands-on activities and classroom lessons will use inexpensive, readily available materials. Teachers will be shown how to translate the watershed explorations to their school sites ensuring that these experiences will be available to all students (Objective 3).

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e. Utilizing of NOAA programs and personnel

Interpreting the Bay will utilize NOAA products (see supporting documents) and deepen the partnership between the Exploratorium and NOAA entities GFMNS and NERR (Objectives 1 and 2). Support of classroom visits by GFNMS will contribute to curriculum development and audience reach of both organizations (Objective 4).

NOAA and the Exploratorium currently have a five-year partnership to bring modern climate science and ocean research to the public. At the Exploratorium's new site, NOAA research vessels will be able to dock at Piers 15/17, and NOAA scientists will conduct research in the museum's in-house laboratory. Experience from this project about the design of successful teacher professional development strategies will inform how TI translates NOAA research into successful classroom teaching and learning experiences. Moreover, newly developed environmental education activities will be used at the Exploratorium's waterfront location with all museum audiences, which will give these lessons long-term authenticity and relevance.

f. Aligning with the NOAA Education Plan and NOAA Ocean Literacy Principles

Interpreting the Bay will directly support NOAA's Education Strategic Plan Goal 1 (An environmentally literate public supported by a continuum of lifelong formal and informal education and outreach opportunities in ocean, coastal, Great Lakes, weather, and climate sciences). Activities and NOAA products and partners will promote Outcomes 1.2 (Educators understand and use environmental literacy principles) and 1.3 (Educators, students, and/or the public collect and use ocean, coastal, Great Lakes, weather, and climate data in inquiry and evidence-based activities). Watershed experiences for teachers will allow them to better understand scientific research, promote environmental stewardship, connect them to nature and the community, and use emerging technologies (such as *Marine Debris Tracker*), all strategies outlined in the Education Plan. By translating these experiences to the classroom, TI will help teachers use inquiry and experience-based activities to understand and teach environmental literacy principles (Objectives 1 and 2). TI's partnership with GFNMS will expand the impact of both institutions (Outcome 1.5: NOAA works cooperatively to maximize the impact of federal investment in ocean, coastal, Great Lakes, weather, and climate education; Objective 4).

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By studying measurable properties of the Bay, *Interpreting the Bay* will explore topics aligned with NOAA Ocean Literacy Principles on the connectedness of the Earth’s water reservoirs, the water cycle, ocean currents, ocean life, and human activity (Objectives 1 and 2). Looking at specific properties of water and the watershed environment will highlight the California Education and Environment Initiative Principle III (Natural systems proceed through cycles that humans depend upon, benefit from, and can alter) and IV (The exchange of matter between natural systems and human societies affects the long term functioning of both). These will be connected to California State Science Content Standards through classroom activities (Table 2).

Table 2: Example of *Interpreting the Bay* topic mapped to CA Science Content Standards, NOAA Ocean Literacy Principles, and Classroom Activities

Example of Prof. Dev. Topic	CA Science Standards	NOAA Ocean Literacy Principles	Classroom Activities
Salinity and density	<ul style="list-style-type: none"> Students know density is mass per unit volume (Grade 8, 8A) and how to calculate the density of substances from measures of mass and volume (Grade 8, 8B). Students know how to calculate the concentration of a solute in terms of grams/liter, molarity, ppm, and percent (Chemistry Grades 9-12, 6D). 	<ul style="list-style-type: none"> Most of Earth’s water (97%) is in the ocean. Seawater has unique properties: it is saline, its density and its electrical conductivity are higher than fresh water, and it is slightly basic (1E). The ocean is connected to major watersheds. Rivers and streams transport nutrients, salts, sediments, and pollutants from watersheds to estuaries and to the ocean (1G). 	<ul style="list-style-type: none"> <i>Water Quality from Data in the Classroom</i>: Create and interpret real time salinity data from NOAA web sources. Map the locations of instruments. <i>Tasting the Tides</i>: Make different saline solutions to match real estuary data. <i>Hydrometer</i>: Construct a simple tool to measure density of saline solutions. <i>Conductivity Meter</i>: Build a simple version to understand electrical conductivity of solutions.

In addition, these activities will directly support the emergent NGSS, specifically in Science and Engineering Practice (developing and using models, analyzing and interpreting data, using mathematical and computational thinking, and obtaining, evaluating, and communicating thinking), Disciplinary Core Ideas (earth systems, impacts and processes, matter and chemical reactions, and engineering design), and Crosscutting Concepts (systems and systems models, structure and function, cause and effect, stability and change, and patterns).

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2G. Program Location

The *Interpreting the Bay* Summer Institute and Saturday content workshops will be conducted at the Exploratorium's new location at Piers 15/17 on the San Francisco Bay and will include a Saturday workshop field experience at the GFNMS Visitor Center. Teacher participants from SFUSD and OUSD will therefore be doing activities in their local watershed.

3. PROGRAM PERSONNEL

3A. Organization Leads

This project leverages the Exploratorium Teacher Institute's 28-year history of providing high-quality professional development, innovative education materials and resources, content and pedagogy expertise, and online support to more than 2,700 science teachers. TI has been recognized as an exemplar of teacher professional development by the U.S. Dept. of Education's National Commission on Mathematics and Science Teaching for the 21st Century (John Glenn Commission) and by the National Center for Improving Science Education. In a double-blind survey of over 1,000 TI alumni conducted by Inverness Research Associates, 75% rated the program as the single best science education resource available to them, and 95% rated the value of the program as high to very high⁶. The mission of TI is to help teachers increase science content knowledge, improve pedagogical skills, develop leadership skills, and, most importantly, infuse their teaching with authentic, inquiry-based science teaching and learning experiences. This is achieved using engaging, content-rich instructional methods that mirror those to be used with students, allowing teachers to reflect on their practice, and creating a long-lasting community of educators - all hallmarks of effective professional development programs⁷.

Principal Investigator, [REDACTED] is a Staff Scientist in the Teacher Institute. Since joining the Exploratorium, [REDACTED] has led two NSF-funded projects on creating teacher professional development programs in novel content areas. Project Director, [REDACTED], is a Staff Educator who develops and leads workshops for the Teacher Institute. She is an award-winning teacher with expertise in math and science education. [REDACTED] served as project director for *WET FEET* and other TI environmental science programs. Both [REDACTED] are former classroom teachers who participated in TI programs before joining the staff.

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For *Interpreting the Bay*, [REDACTED] will collaborate with other TI staff scientists and educators to deliver and manage the content for the Summer Institute and Saturday workshops. They will work with school district partners to recruit teacher participants and with organizational partners to develop meaningful watershed experiences for teachers. Additionally, they will conduct and analyze findings from front-end and formative evaluations to improve program elements and inform a summative evaluation.

3B. Partners

Gulf of the Farallones National Marine Sanctuary (GFNMS) - The GFNMS is a complex region with high biological diversity; nationally significant wildlife breeding and foraging areas; significant commercial and recreational fishing; estuarine habitats; numerous federally, state, and locally protected marine and estuarine waters; and watershed impacts from 8,000,000 Bay Area residents. Staff are committed to help solve sanctuary management problems, enhance ecosystem protection, assist in interpretation of the ecosystem for the public, and provide content for teacher professional development. Justin Holl, Visitor Center Manager, will co-develop and co-lead a Saturday workshop, focusing on a topic identified by GFNMS staff. Furthermore, this project will support classroom visits by GFNMS to secondary schools, a desired audience.

National Estuarine Research Reserve (NERR) - The focus of the San Francisco Bay NERR is to support tidal marsh restoration through research, monitoring, and education. NERR guides and coordinates research within the reserve sites; conducts long-term monitoring of water quality, weather, and biological systems; fosters stewardship to protect and enhance reserve sites; offers education for science teachers and the public; and provides training for coastal decision makers. NERR is committed to helping teachers use estuarine data and research in classrooms. Sarah Ferner, NERR Education Coordinator, will co-lead a Saturday workshop on the use of data loggers and accessing and interpreting real-time San Francisco Bay data from their field station.

4. PROJECT TIMELINE

The project will begin on August 1, 2013 and conclude July 31, 2014. Preliminary participant recruitment and planning will occur before the start date.

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Table 3. *Interpreting the Bay* Timeline

Activity	spring 2013	summer 2013	fall 2013	spring 2014	summer 2014
Participant Recruitment	██████	██████	██████	██████	
Summer Institute (development/delivery)		██████████████			
Saturday Workshops (development/delivery)			████████████████████		
Formative Evaluation		████████████████████			
Summative Evaluation				██████████████	██████████████

5. PROJECT EVALUATION

The *Interpreting the Bay* evaluation will provide both qualitative and quantitative data to assess whether the program is meeting the following goals:

- 1) to increase teacher content knowledge of watershed science and water data instrumentation, collection, and interpretation, including its ties to human impacts on the watershed
- 2) to strengthen the skills and capacities of middle and high school science teachers to facilitate meaningful watershed experiences for their students that are both place-based and classroom-based
- 3) to provide opportunities for teachers to collaborate and share content and activities with their peers
- 4) to expand GFNMS teacher outreach and the development of more hands-on approaches

A logic model and sample evaluation instruments that will be used to assess the extent to which the project meets the expected outcomes are included in the appendix. TI will conduct a content-based test prior at the start and at the end of the Summer Institute. Comparing data from the pre- and post-tests will reveal whether teachers developed stronger content knowledge.

Formative evaluation will include an online Workshop Evaluation Survey to ensure *Interpreting the Bay* is meeting its objectives and serving the content and pedagogical needs of participants. Surveys will be sent to participants following each program element and analyzed to assess the overall quality of the program. The post-Summer Institute Evaluation Survey will include items to determine the effectiveness of the institute’s dedicated collaboration and project time.

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To monitor and track changes in classroom practice, TI will use an online Classroom Practice Survey, an effective tool developed for *WET FEET*. Participant responses will be used to: 1) monitor if and how teachers are incorporating program materials into their curricula and document any challenges they faced, and 2) determine which activities have been most useful. TI will send Classroom Practice Surveys to all program participants at the end of the school year (June, 2014). These surveys will also allow teachers who have a GFNMS staff educator visit their classroom to provide feedback on the effectiveness of this program element. Teachers will receive a \$10 stipend for completing the Classroom Practice Survey.

TI will use online Teacher Portfolios to monitor how Summer Institute participants are engaging in peer-to-peer sharing and disseminating program materials and activities. Teacher Portfolios will be modeled during the Summer Institute, and teachers will use them to report dissemination to other teachers through professional development venues such as school staff development meetings, district professional development meetings, and science teacher conferences. Summer Institute participants will receive a \$100 stipend for completing a Teacher Portfolio.

In the summative phase, TI will assess how well the project met its proposed outcomes using qualitative and quantitative data (see expected outcomes at the end of Section 6). To evaluate the new collaboration elements with GFNMS, TI will meet with GFNMS staff in June, 2014 to discuss the effectiveness of this pilot program. Results from all instruments, surveys, and interviews will be used to create and improve TI's future professional development programs in environmental science.

6. EXPECTED BENEFITS AND RESULTS

Accomplishments to date:

TI is currently in the third year of *WET FEET*, which combines classroom activities and field experiences related to the San Francisco Bay watershed to strengthen content knowledge and pedagogical skills of teachers. Originally funded by NOAA B-WET, this work is currently supported by the S. D. Bechtel, Jr. Foundation. The objectives of *WET FEET* were:

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1. To design and implement a teacher professional development program to provide teachers with content and pedagogy needed to teach watershed science
2. To increase teacher content knowledge of watershed science
3. To strengthen teachers' pedagogical skills to teach watershed science
4. To develop teachers' skills for peer-to-peer sharing of content, pedagogy, and activities that support teaching of watershed science

The results and accomplishments for each year of the project are described below.

***WET FEET, Year 1* (NOAA B-WET: ██████████)**

In Year 1, the content focus was the impacts of plastics and marine debris in the watershed. The project consisted of hands-on classroom-based and place-based activities offered through a one-week Summer Institute, two Saturday Content Workshops, and one evening workshop. TI staff presented *WET FEET* activities at the 2011 Bay Area Environmental Education Resource Fair and at the 2011 Maker Faire. TI directly served 81 educators and provided 538 hours of professional development. Through documented peer-to-peer sharing, the project served an additional 72 educators and 640 students. The resources created through this project are available for free online and continue to be shared in TI programs.

WET FEET was evaluated using surveys, pre- and post-tests, and Teacher Portfolios. A five-point Likert scale (5=very strongly agree; 1=very minimally agree) was used to quantify teacher reactions. Results from teacher surveys indicated all four project objectives were met and can be summarized as follows: participants felt that *WET FEET* had substantially increased their content knowledge of watershed science and marine debris (mean=4.08), increased their awareness of NOAA education resources for teaching watershed science (mean=3.90), provided them with an avenue for sharing their content knowledge and teaching practices with other teachers (mean=4.42), and encouraged them to engage students in place-based learning (mean=4.33). Moreover, when teachers were asked to describe the features of *WET FEET* that were especially valuable for them, the most frequently cited aspects of the program included participating in field trips that modeled place-based learning strategies (61%), access to low-cost, hands-on classroom activities (38%), having opportunities to network with their peers (15%), and learning about watershed science from guest scientists (15%).

NOAA California Bay Watershed Education and Training Program

The following conclusions were used to inform the development of the *Interpreting the Bay* program: (1) teachers want access to scientists and content-rich resources, including those offered through NOAA, (2) teachers want more access to hands-on activities and other education resources, (3) teachers want more field-trip experiences designed to help them lead their students in meaningful place-based science activities, and (4) teachers deeply appreciate and need opportunities to network with peers to share ideas about teaching watershed science.

WET FEET, Year 2 (S. D. Bechtel, Jr. Foundation: \$65,000)

In Year 2, the content focus was the water cycle, including the impacts of erosion, run-off, and human impacts such as mining and pollution. The project provided a series of six Saturday professional development workshops during the 2011-12 academic year. Four of these workshops were co-developed and co-presented by TI's environmental education and NOAA partners (Literacy for Environmental Justice, Marine Science Institute, GFNMS, and NERR) and were conducted in the field, with TI's partners providing off-site locations for watershed experiences. TI served 90 individual teachers through 6 workshops, with many attending more than one workshop, for a total of 444 contact hours of professional development. The 90 participants teach 13,500 students per day.

Survey results indicated that teachers strongly felt that workshops helped them increase their knowledge about the Bay and watershed-related impacts. Of the 49 survey respondents, 73% selected 4 or 5 on a Likert scale when asked to assess the extent to which the workshops "had increased their science knowledge" (1=not at all, 3=average, and 5=a lot). The development and implementation of a Classroom Practice Survey proved to be a valuable tool for providing information on which activities teachers found most useful and whether teachers were incorporating these activities into their classroom practice. Of 33 teachers who responded, 58% had used one or more activities from these workshops in their classrooms, and 88% planned to use activities by the end of the school year, showing a great potential for changing classroom practice and reaching many students. Analysis of survey comments indicated that teachers were very satisfied with the quality of the workshops.

NOAA California Bay Watershed Education and Training Program

***WET FEET*, Year 3 (in progress; S. D. Bechtel, Jr. Foundation: \$65,000)**

In Year 3, TI has focused on the new NGSS and their increased emphasis on engineering practices. To leverage the museum's Wired Pier project, TI offered a one-week institute, "The Unwired Pier", in summer, 2012. This institute was designed to complement the collection of technical instruments that will gather real-time data about the pier location's changing atmospheric and aquatic conditions. Teachers explored the Bay environment through hands-on investigations and data gathering tools, many built by teachers themselves. This institute's materials and activities provide a foundation on which to build more content and activities for *Interpreting the Bay*. In this way, TI will continue to leverage the *WET FEET* project to provide resources and activities for teacher professional development and future museum programs. Additionally, three Saturday workshops are planned for fall, 2012 and will be co-developed with TI's partners. Year 3 activities have not yet been evaluated.

***Interpreting the Bay* Expected Outcomes**

- 1) Data showing a significant improvement in content knowledge of participants as measured by pre- and post-tests about watershed science, data collection, and data analysis
- 2) Data showing an increase in the frequency with which participants use place-based learning strategies and experiential, student-centered activities in teaching watershed science through data collection and analysis as measured by Classroom Practice Surveys
- 3) Data demonstrating that participating teachers shared watershed-related classroom activities and place-based learning strategies with peers as measured by Teaching Portfolios
- 4) Data demonstrating increased secondary school visits by GFNMS in-school programs

7. OUTREACH AND EDUCATION

TI-developed *Interpreting the Bay* activities, as well as links to curriculum developed by NOAA and other organizations, will be posted on the Exploratorium Web site, which receives more than 13 million visitors a year. Summer Institute participants will be given collaboration time each day to discuss experiences, activities, and curriculum. They will be encouraged to share project experiences with other teachers at their schools and through other dissemination activities. TI will create a streamlined, online process to help participants report their dissemination through Teacher Portfolios. TI staff will present program elements in workshops and short courses at

NOAA California Bay Watershed Education and Training Program

local and national conferences. Finally, *Interpreting the Bay* activities and curriculum will be essential as the Exploratorium continues to develop its long-term partnership with NOAA and creates meaningful watershed experiences for visitors in its new home at Piers 15/17.

8. BUDGET NARRATIVE

Please see attached.

9. LETTERS OF SUPPORT

Please see attached for letters of support from project partners:

Justin Holl, GFNMS
Sarah Ferner, NERR
Jeanne D'Arcy, SFUSD
Caleb Cheung, OUSD

9. SUPPORTING DOCUMENTS

Please see attached for resumes of [REDACTED], *Interpreting the Bay* Logic Model, Evaluation Instruments, and Curriculum Resources.

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⁵ <http://www.ed-data.k12.ca.us>

⁶ Hirabayashi and Stokes (2006) www.inverness-research.org/reports/2006-06-Rpt-ExploreTI-RoleTeachingScience.pdf

⁷ Guskey, T. R. (2003). Analyzing lists of the characteristics of effective professional development to promote visionary leadership. *NASSP (National Association of Secondary School Principals) Bulletin*. 87(637), 38-54.

Interpreting the Bay Logic Model

Audience: 125 middle and high school science teachers

Overall Goals: To increase teacher content knowledge of water data instrumentation, collection, and interpretation and its ties to human impacts on the watershed; to strengthen the skills and capacities of middle and high school science teachers to facilitate meaningful watershed experiences for their students that are both place-based and classroom-based; to provide opportunities for teachers to collaborate and share content and activities with their peers; to increase capacity and reach of GFNMS and TI programs

Objectives	Resources	Activities	Outputs	Short-term Outcomes	Mid/long-term Outcomes/Impacts
Audience will show increased content knowledge of watershed science through data collection and analysis	·Data in the Classroom and other NOAA Web sites ·TI developed activities and curriculum	·Participant recruitment ·Activity development ·Workshop planning ·Partner coordination ·Planning with TI staff scientists and teachers	·Summer Institute ·Saturday workshops ·GFNMS classroom visits	·Increased knowledge of watershed science, data collection and analysis	·Increased incorporation of environmental topics into standard curricula
Audience will increase teaching repertoire regarding watershed science, data collection and analysis	·Data in the Classroom and other NOAA Web sites ·Marine Debris Tracker application ·TI developed activities and curriculum	·Participant recruitment ·Activity development ·Workshop planning ·Partner coordination ·Planning with TI staff scientists and teachers	·Summer Institute ·Saturday workshops ·GFNMS classroom visits	·Increased teaching of watershed science ·Incorporation of place based and classroom based activities ·Direct incorporation of activities into curriculum	·Increased incorporation of environmental topics into standard curricula ·Long-term collaborations with GFNMS
Audience will share program content with peers		·Teacher planning time and resources provided during Summer Institute	·Teacher produced lessons on watershed education ·Teacher Portfolios ·GFNMS classroom visits	·Dissemination of workshop and institute activities to peers ·Direct incorporation of activities into curriculum	·Utilization of project resources by teachers beyond workshop participants ·Long-term collaborations with GFNMS
GFNMS will deliver new content in school programs to teacher participants	·TI and GFNMS developed activities and curriculum	·Workshop planning ·Partner coordination ·Planning with TI staff scientists and teachers	·GFNMS classroom visits	·Enhanced curriculum and increased site visits for GFNMS in-school programs	·Establish long-term collaborations between GFNMS and secondary teachers

Interpreting the Bay Evaluation Instruments

I. Evaluating Teacher Content Knowledge: Pre- and Post-tests

TI will create content-based pre- and post-tests to administer to the teachers in the Summer Institute. Test items will include content-based evaluation items created by TI staff that will be aligned with overlapping content from the California State Science Content Standards and the NOAA Ocean Literacy Principles.

II. Evaluating Program Quality: Sample Summer Institute and Workshop Evaluation

1. What activities or presentations were most useful to you? Why?
2. To what extent did this workshop: (Scale: 1=none, 2=a little, 3=some, 4=a lot, 5=a great deal)
 - a. increase your science content knowledge of watershed science?
1 2 3 4 5
 - b. increase your understanding of water quality data collection and interpretation?
1 2 3 4 5
 - c. increase your knowledge of current critical issues affecting our watershed and sanctuary?
1 2 3 4 5
 - d. increase your awareness of NOAA and other resources for teaching watershed issues?
1 2 3 4 5
 - e. encourage you to share content knowledge of watershed issues and/or teaching activities and methods with other teachers?
1 2 3 4 5
 - f. encourage you to engage your students in “place-based” learning of watershed science?
1 2 3 4 5
3. What topics would you like to see in future workshops?

III. Evaluating Changes in Classroom Practice: Classroom Practice Surveys

Participants from all program elements will be surveyed to see how they are incorporating program materials into their curricula. The Classroom Practice Survey will be conducted using a web-based tool and sent to the teachers in June, 2014. The survey will also be use to evaluate the effectiveness of the Gulf of the Farallones National Marine Sanctuary classroom visits. Respondents will receive a \$10 stipend.

IV. Evaluating Peer-to-Peer Sharing: Teacher Portfolios

To facilitate *Interpreting the Bay* dissemination, the Teacher Institute will provide stipends and encourage teachers to share institute experiences and activities with peers. Teachers will be paid \$100 for Teacher Portfolio submissions documenting their peer-to-peer sharing.

Teacher Portfolio Components

- 1) Name, Presentation Venue, Number of Teachers
- 2) Date and Presentation Agenda
- 3) Source of the lesson or activity
- 4) A short summary/reflection of how the presentation went

Interpreting the Bay Curriculum Resources

The Exploratorium Teacher Institute develops many of its own materials for its workshops and programs. This list provides examples of NOAA products and other curricular materials that will be used in addition to those developed by TI.

NOAA Products:

1) *Data in the Classroom* - <http://www.dataintheclassroom.org/>

Activities: Monitoring Estuarine Water Quality and Ocean Acidification Modules

2) National Estuarine Research Reserve

Graphing Tool - <http://estuaries.noaa.gov/ScienceData/Graphing.aspx>

3) National Estuarine Research Reserve

High School Estuaries 101 Curriculum

Earth Science Module - <http://estuaries.noaa.gov/Teachers/HighSchool.aspx>

Activities: Salinity and Tides in the York River and Estuary and Watershed-San Francisco Bay

4) National Estuarine Research Reserve

Middle School Estuaries 101 Curriculum

Activity: Seasonal Swings - <http://estuaries.noaa.gov/Teachers/seasonal-swings.aspx>

Activity: Water Going Up, Water Going Down - <http://estuaries.noaa.gov/Teachers/water.aspx>

5) National Estuarine Research Reserve

Using Google Earth to Explore Estuaries

<http://estuaries.noaa.gov/Teachers/Default.aspx?ID=299>

Other Curricula and Resources:

6) California Coastal Commission

Waves, Wetlands, and Watersheds - <http://www.coastal.ca.gov/publiced/waves/waves1.html>

Activities: Keep Your Head Above Water, The Edge of the Wedge

7) The California Education and the Environment Initiative (EEI) Curriculum in Earth Science

<http://www.calepa.ca.gov/Education/EEI/Curriculum/EarthScience/Default.htm>

Selected lessons from Liquid Gold: California's Water and Ocean Currents and Natural Systems

8) Save the Bay

San Francisco Bay Watershed Curriculum - <http://www.savesfbay.org/watershed-curriculum>

Activity: Watershed in Your Hands

9) “Unwired Pier” Summer Institute 2012

TI developed or presented these materials for this institute as part of the *WET FEET* project, which will provide a foundation for *Interpreting the Bay*.

<https://docs.google.com/a/exploratorium.edu/document/d/1FALiO78gLiV4S8XOYnd1CBIPiXbXjQlqVN9eaIES4Lk/edit>